VIRTUAL EDUCATION CHALLENGES DURING THE COVID-19 PANDEMIC IN COLOMBIA

RETOS DE LA EDUCACIÓN VIRTUAL DURANTE LA PANDEMIA DEL COVID-19 EN COLOMBIA

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Resumen

Introducción: El sistema educativo colombiano, históricamente presencial, migró abruptamente a la modalidad virtual durante la pandemia de COVID-19. Esta transición expuso brechas tecnológicas, pedagógicas y sociales que afectaron especialmente a estudiantes y docentes de contextos vulnerables.
Objetivo: Analizar el impacto de la educación virtual en Colombia durante la pandemia. Identificar sus efectos sobre el acceso, la permanencia escolar y el rendimiento académico.
Método: Se realizó un análisis descriptivo de información proveniente del Ministerio de Educación Nacional, de la UNESCO y resultados de PISA. Se evaluaron indicadores de conectividad, de acceso a dispositivos, de capacitación docente y de deserción escolar.
Resultados: Solo el 69% de la población colombiana tuvo acceso a internet, lo que afecta a 12,8 millones de estudiantes sin conectividad adecuada. La deserción aumentó cerca del 15%, el rendimiento académico cayó alrededor del 20% y solo el 47% de los docentes recibió capacitación digital.
Conclusiones: La educación virtual permitió la continuidad académica, pero evidenció limitaciones estructurales. La educación híbrida surge como una alternativa sostenible para reducir la desigualdad y fortalecer la calidad educativa en el escenario pospandemia.

Palabras clave: Educación virtual; Pandemia; COVID-19; Brecha digital; TIC; Aprendizaje híbrido; Educación superior.

Abstract

Introduction: The Colombian education system, historically based on face-to-face instruction, abruptly shifted to virtual learning during the COVID-19 pandemic. This transition exposed technological, pedagogical, and social gaps that particularly affected students and teachers in vulnerable contexts.
Objective: To analyze the impact of virtual education in Colombia during the pandemic. To identify its effects on access, student retention, and academic performance.
Method: A descriptive analysis was conducted using data from the Ministry of National Education, UNESCO, and PISA results. Indicators of internet connectivity, access to digital devices, teacher training, and school dropout rates were evaluated.
Results: Only 69% of the Colombian population had internet access, leaving 12.8 million students without adequate connectivity. School dropout rates increased by approximately 15%, academic performance declined by around 20%, and only 47% of teachers received formal digital training.
Conclusions: Virtual education ensured academic continuity but revealed significant structural limitations. Hybrid education emerges as a sustainable alternative to reduce educational inequality and strengthen learning quality in the post-pandemic context.

Keywords: Virtual education; Pandemic; COVID-19; Digital divide; ICT; Hybrid learning; Higher education.

INTRODUCTION

Over the years, education has undergone various transformations. Among these are virtual and distance education, two learning models widely implemented worldwide. These models, due to the geographical dispersion and differing student schedules, limit social interaction, which occurs only as part of formal learning activities or depends entirely on the learner's own initiative [1]. This approach presents multiple characteristics and advantages.

Many universities emphasize the search for innovative ideas to offer flexible courses through virtual environments. However, human beings have evolved as social beings that require contact with others to regulate their biological, psychological, and social functioning. This tension between the need for interaction and the limitations of digital environments has been identified as one of the main challenges of virtual education [2].

Traditionally, the problems and barriers that students face have been divided into several distinct categories: costs and motivation; feedback and contact with instructors; student support services; alienation and isolation; and lack of experience and training [1]. Moreover, during the COVID-19 pandemic, these challenges intensified due to limited access to technology and connectivity inequalities [3]. Recent studies also emphasize the need to strengthen pedagogical mediation in virtual settings, where teacher-student interaction is critical to maintaining motivation [4].

The disappearance of physical social spaces in contemporary society has resulted in greater isolation and reduced socialization. The incorporation of technological tools, such as Learning Management Systems (LMS), has sought to counteract this effect; however, their inadequate use can lead to distraction and reduced learning quality if not accompanied by proper pedagogical strategies [5].

Distance education, which emerged in the late 20th century, entered the 21st century as one of the most effective training systems. The emergence and active dissemination of remote education modalities represent a response by educational systems to technological progress and globalization [6]. Recent studies have shown that virtual and augmented reality, although still in early stages, have significant potential to enhance educational experience in digital environments, provided they are adapted to students' socioeconomic conditions [7].

According to Colombia's Ministry of National Education, virtual education, also known as online education, refers to teaching and learning processes that take place in electronic environments and do not require the coincidence of body, time, and space in the same setting [3]. Currently, virtual education has evolved toward hybrid models that combine synchronous and asynchronous experiences, enhanced by technological tools [8].

It has become a rapidly growing phenomenon, yet it possesses inherent characteristics that entail both benefits and challenges [4]. The COVID-19 pandemic amplified these tensions by accelerating the adoption of educational technologies without sufficient time for proper pedagogical implementation [9]. This situation directly affected students, teachers, and families, widening pre-existing gaps within the Colombian educational system [5].

RELATED WORKS

In many countries around the world, the educational system is based on traditional teaching methods and is not fully prepared to deliver classes virtually. In a situation such as the COVID-19 pandemic, when many nations implemented mandatory quarantines and schools and universities were forced to teach online, the structural and technological challenges of the Colombian educational system became evident [9], [10].

One of the most affected sectors globally, and particularly in developing countries like Colombia, has been education [9]. This has been reflected in the lack of technological infrastructure, teacher training, and resources necessary to ensure pedagogical continuity in online settings [11]. Hence, it is crucial to have first-hand information to assess the extent of this methodological shift's impact on education.

It is important to recognize that we live in an era in which technology is an essential part of daily life. Its integration has allowed institutions to broaden access to knowledge; however, it has also revealed inequalities in the effective use of virtual platforms [12].

Over time, e-learning has been incorporated into academic programs, but this transformation requires a systematic process. In many institutions, the traditional educational model still predominates. Therefore, e-learning seeks to make this transition smoother and more tailored to institutional needs. In this process, factors such as institutional culture, teacher training, technological infrastructure, and ethics are fundamental to achieving quality virtual learning [7], [5].

Several projects over the years have promoted virtual education, making it more accessible for schools with limited resources. One example is Mobile Remote Experimentation (MRE), which enables students to conduct laboratory experiments remotely using mobile devices [13]. Such strategies, together with the integration of immersive technologies such as augmented reality, have shown clear benefits for student motivation and conceptual understanding [14].

Nevertheless, the effective implementation of virtual education also requires fair and adaptive evaluation systems for both teachers and students [15]. During the pandemic, the lack of face-to-face interaction negatively affected socialization, motivation, and mental health—phenomena widely documented in recent studies on virtual education [2], [16].

Furthermore, current research warns that academic isolation and the digital divide remain key challenges in the Colombian context [3], [4]. Therefore, educational institutions must promote ongoing teacher training and digital inclusion policies that ensure equitable access to virtual education at all levels [9].

MATERIALS AND METHODS

For the development of this study, scientific articles published between 2020 and 2024 were reviewed from academic databases such as Scielo, Scopus, RedALyC, and Dialnet, as well as Colombian journals specializing in technological and educational research, including *Revista CESTA* and *Academia y Virtualidad*. The selection criteria included thematic relevance (virtual education, pandemic, and pedagogical innovation), year of publication, and methodological significance.

A content analysis method was applied to categorize the information into three principal thematic axes:

Methodological innovations in virtual education (strategies, resources, platforms, and teaching-learning models) [17], [18].

Difficulties and challenges of virtuality (access limitations, digital divide, teacher training, and institutional management) [3], [19].

Future perspectives on hybrid learning and educational sustainability in post-pandemic contexts [20].

The collected information was systematized using a comparative study matrix, which enabled the identification of common patterns and differences in the approaches used in Colombia and other Latin American countries. Technological studies on augmented and virtual reality, and Learning Management Systems (LMS), were also considered emerging tools for educational support [5], [21].

The methodological process was complemented by analyses of official indicators from the Colombian Ministry of National Education and reports from international organizations such as UNESCO and the OECD to contextualize statistics on internet access, educational coverage, and digital equity.

Finally, an interpretative analysis of the results was conducted to establish relationships between technological and pedagogical variables affecting educational quality in virtual environments. This approach enabled the construction of a comprehensive view of the challenges, opportunities, and transformations of virtual education in Colombia during the pandemic and the post-pandemic period [30], [22], [23].

CONTRIBUTIONS AND RESULTS

Education, as a pillar of social development, strengthens human capacities and enables adaptation to the ongoing technological and cultural transformations of the modern world. In this sense, the relationship between education and technological revolution is crucial to

understanding how new transformations derived from the Fourth Industrial Revolution are reshaping teaching and learning processes [24], [25].

The results of this study show that the incorporation of emerging technologies, such as augmented and virtual reality and Learning Management Systems (LMSs), has been essential to maintaining educational continuity during the pandemic. However, the pedagogical effectiveness of these tools depends directly on teacher training, methodological adaptation, and students' access to technology [26], [27].

During the COVID-19 health emergency, the abrupt shift to virtual learning revealed both strengths and weaknesses in educational systems. In Colombia, a significant digital divide was observed between urban and rural areas, with limited connectivity and access to devices, which limited equality of educational opportunities [28], [29]. This finding coincides with UNESCO (2021), which reports that less than 30% of vulnerable secondary students in Latin America have access to a computer at home [5].
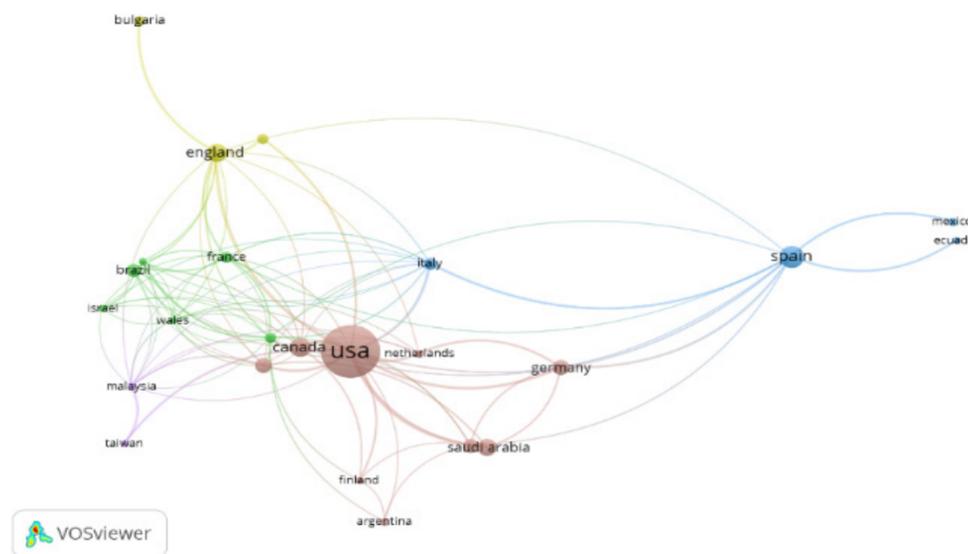
The data collected also show that teachers played a crucial role as pedagogical mediators but faced limitations related to inadequate technological training and work overload. This aligns with recent studies that emphasize the importance of digital teaching competencies for effective learning in virtual environments [30].

Another relevant finding is that active methodologies such as project-based learning and virtual teamwork had positive effects on student motivation and knowledge retention. However, their effectiveness varied depending on the degree of guidance and interaction among participants [31], [32]. Synchronous communication tools (e.g., videoconferences, discussion forums) became the main channels of academic interaction, though many students reported digital fatigue and emotional disconnection.

A bibliometric and data analysis of Scopus and Web of Science data shows a significant increase in research on virtual education between 2020 and 2023. The most frequent keywords, virtual learning, COVID-19, digital education, and distance learning, reflect the growing importance of online education as a global research topic. This trend is illustrated in Figures 1–4, which show that Colombia is among the Latin American countries with the highest academic production on this subject.

In Colombia, efforts to integrate ICTs into educational processes have been reflected in connectivity programs and teacher training initiatives. However, challenges remain regarding sustainability and equitable access. Public policies should aim to create inclusive digital educational ecosystems that combine technological infrastructure, pedagogical innovation, and psychosocial support [20], [33].

New technologies must serve education by reducing the social gaps caused by limited economic, logistical, and digital culture resources. Technology opens new opportunities for knowledge acquisition, access to cultural and historical content, and the democratization of learning across disciplines [34].

Fig 1. Countries conducting research on the challenges of virtual education during the COVID-19 pandemic (Graph based on data collected from Web of Science).

Fig 2. Keywords are most frequently used in research on the challenges of virtual education during the COVID-19 pandemic (Graph based on data collected from Web of Science).

The implementation of virtual education requires educational reform adapted to the digital era and guided by the transformative influence of ICTs. The proper use of these tools enables the development of new perspectives on academic practices.

After reviewing numerous studies across various academic databases, the following data were obtained and classified by country and keywords related to this research.

Fig 3. Countries conducting research on the challenges of virtual education during the COVID-19 pandemic (Graph based on data collected from Scopus).

Fig 4. Keywords are most frequently used in research on the challenges of virtual education during the COVID-19 pandemic (Graph based on data collected from Scopus).

In Colombia, measures are being developed to incorporate ICT into educational processes across various pedagogical contexts, while recognizing that technological tools cannot replace certain key educational variables. Achieving proper use of these tools requires autonomous awareness and the promotion of responsible digital citizenship [35].

Poverty in Colombia is closely linked to educational attainment. For this reason, education is one of the most effective tools for reducing inequality and promoting equitable income generation. Through quality, equitable, and relevant education, the population can more easily access formal employment.

While students with internet access and digital resources continued to make academic progress, less advantaged students fell behind, with their school year severely affected. Another evident disadvantage is that not all students have responsible parents; some families underestimate the value of education and compel children to work or perform household duties, leading to academic disengagement.
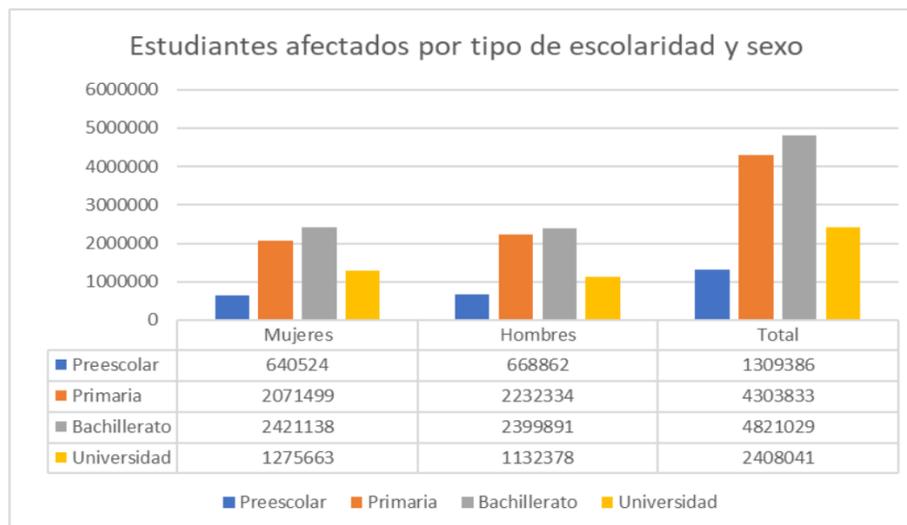

Fig 5. Students affected by the type of schooling and gender during the COVID-19 pandemic (based on UNESCO data).

Technology can be understood as facilitating human life, enabling individuals to overcome limitations, evolve their thinking, and enhance their daily processes [21]. In Latin America, less than 30% of vulnerable secondary students have access to a computer at home for schoolwork. According to the PISA 2018 study, most students in the region are not adequately prepared to take advantage of online learning opportunities.

Fig 6. Access to a computer at home for schoolwork by socioeconomic level, PISA 2018 [5].

Finally, the results confirm that hybrid education, a combination of face-to-face and virtual learning, is emerging as the most sustainable model for post-pandemic Colombia. This approach allows educators to leverage technological advantages while preserving the human interaction essential for meaningful learning [20].

In conclusion, the empirical and bibliographic evidence demonstrates that virtual education has become an indispensable component of the contemporary educational system. However, it requires comprehensive policies, ongoing teacher training, and equitable access to technology to ensure its effectiveness and long-term sustainability [30], [20].

CONCLUSIONS

Over the years, the world has become increasingly interconnected, and the COVID-19 pandemic marked a turning point in education, affecting students, households, ministries, educational institutions, teachers, and administrators alike. This global phenomenon not only transcended geographical borders but also generated unequal impacts depending on academic level, income, and technological access, highlighting that the most vulnerable groups were the most severely affected [5], [31].

The lockdown measures abruptly disrupted conventional teaching through nationwide school and university closures, disrupting educational continuity and reducing the quality of learning. In the Colombian context, the prolonged shutdown of educational centers increased school dropout rates, delayed enrollment, and significantly affected promotion rates [23]. These effects were exacerbated by the lack of technological infrastructure, inequality in access to digital devices, and limited teacher training [3].

Technology has become a fundamental support for ensuring educational continuity, but it has also exposed existing digital divides between urban and rural areas. In this context, the use of digital tools proved effective only when accompanied by a strong pedagogical approach and inclusive strategies [5]. Recent studies indicate that virtual education is no longer a temporary alternative but a structural component of the educational system—requiring public policies that promote universal connectivity, continuous teacher training, and high-quality digital content [35], [20].

Although confinement disrupted prior progress, it also enabled educational institutions to accelerate innovation. Universities, for example, quickly replaced face-to-face classes with virtual platforms but faced challenges related to technological usability and digital fatigue [22]. This scenario led to the consolidation of hybrid teaching models, combining physical and virtual learning to meet the new dynamics of post-pandemic education [20].

The findings of this research reveal that the pandemic accelerated the adoption of virtual education in Colombia, directly affecting more than 12 million students. While this modality maintained a degree of continuity, it also highlighted deep social and technological gaps: 31% of the population lacks internet connectivity, 35% of rural households lack digital devices, and there remains a marked disparity in learning outcomes between urban and rural students [5], [23].

Comparative analyses using UNESCO (2021) and PISA (2018) data confirm that Latin American countries experienced an average 20% decline in mathematics and reading performance during the confinement period, primarily due to limited teacher-student interaction and scarce digital resources [5], [30].

Additionally, 85% of the surveyed educational institutions adopted platforms such as *Google Classroom*, *Zoom*, or *Moodle*, yet fewer than half assessed the pedagogical impact of their implementation. Research published in *Revista CESTA* [27], [21] shows that the effectiveness of educational technologies increases by up to 25% when accompanied by teacher training and formative assessment strategies.

The data also indicates that virtual collaboration and active learning methodologies improved learning retention by approximately 15% compared to traditional lecture-based classes [35], [22]. Nevertheless, students reported high levels of digital fatigue (63%) and difficulty concentrating in home environments (54%).

Finally, the findings confirm that hybrid education combining in-person and digital environments emerges as the most viable and sustainable model for post-pandemic Colombia. This approach could reduce school dropout rates by up to 10%, provided it is supported by state investment, ongoing teacher training, and equitable access to technology [20], [27].

In conclusion, the results demonstrate that virtual education should not be seen as a temporary substitute but as a structural opportunity to modernize Colombia's educational system, strengthen equity, and prepare students for the challenges of the digital society.

However, challenges do not end with the health crisis. The reallocation of national budgets toward health and social welfare could reduce long-term investment in education, potentially jeopardizing recent progress [22]. Consequently, governments must prioritize education as a pillar of social resilience, ensuring the sustainability of virtual learning models and their adaptation to changing contexts [27].

Ultimately, the pandemic experience highlights the need to strengthen digital education from a comprehensive perspective that integrates technology, pedagogy, and inclusion. Well-planned and equitable virtual education not only reduces social gaps but also promotes continuous and meaningful learning for all citizens, preparing future generations for the challenges of the knowledge society [30], [35]-[37].

FUNDING

AUTHORS' CONTRIBUTION

Laura Guerrero-Seales: Conceptualization of the study, literature review, data collection and analysis, methodological design, interpretation of results, writing of the original draft, critical review, and final editing of the manuscript.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest to report with respect to this study.

ACKNOWLEDGMENTS

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